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Exploring University Campus Community's Perceptions and Barriers toward Biking: A Case Study of the University of Tennessee Knoxville

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Abstract

Bicycling constitutes an integral component of sustainable non-motorized means of travel. Despite the immense benefits of bicycling, the modal share of bicycling is quite low, specifically among young and low-income commuters e.g., college and university students. This study explores the perceptions of and barriers to bicycling of the campus community at the University of Tennessee, Knoxville with the aim to identify the factors that could enhance bike use among students at the university campus as well as highlight the barriers that keep young population away from biking. An online survey about bike use at the university campus was administered and responses to the survey were recorded. On the methodological front, a binary logit model was estimated with students' willingness to use bikes at campus as the dependent variable. The survey results revealed that about 47% of the students considered vehicular traffic as the reason for feeling unsafe while biking and emphasized having separate bike routes. Most of the respondents highlighted the need to change clothes after biking in summer or carry things as the reason for not selecting bikes as a mode of transport at the campus, whereas inadequate bike lanes, paths, or trails, insufficient lighting along bike routes, and the lack of adequate bicycle parking were highlighted as the major barriers deterring bike use within the campus. The study suggests development of a campus bike network with proper bike lanes, bike runnels, installation of safety cameras and better lighting at the campus, and bike-supporting infrastructure such as communal showers to be provided in campus buildings to encourage bike use among university students. The study findings can assist campus transportation planners in devising a sustainable campus transportation plan incorporating the influencing factors and deterrents of bike use in a university campus setting.

Keywords

Bike use, Bike Infrastructure, Educational Institutes, Survey, Binary Logit Model

1. Introduction

Many colleges and universities are interested in promoting sustainable and environment-friendly transportation with a focus on reducing greenhouse gas emissions and relieving local congestion. However, financial, environmental, and spatial constraints are the decisive factors in developing substitute transportation modes [1] [2] [3] [4]. One of the strategies devised to promote alternative non-motorized transportation modes is to provide incentives for alternative transportation modes and disincentives for automobile travel [5] [6] [7]. In line with global sustainability goals, efforts are being made to create a bicycle friendly (non-motorized) environment by including more bicycle infrastructure and sidewalks [8]. Creating environments that support safe and efficient cycling requires thoughtful transportation planning, particularly in high-traffic areas such as university campuses. Proactive measures in conflicting zones are crucial for cyclist safety, with prediction frameworks reducing the likelihood of incidents that cyclists may face in transitional road spaces [9] [10]. Bicycling constitutes an integral part of non-motorized transport, with its benefits including but not limited to low access costs, moderate travel speeds, environment-friendliness, and improved health and well-being making it more appealing to younger and low-income users *i.e.*, college and university students [7] [11] [12] [13]. Despite these benefits, bicycle modal share remains low on many U.S. universities campuses, influenced by a lack of cycling infrastructure, societal norms, and the dimension of race. Transportation planners are searching for ways to bolster cycling at university campuses [5] [14] [15]. The various barriers that can prevent people from cycling include physical obstacles and societal perceptions. The fear of cycling, which encompasses the fear of risk and being judged, is a significant sociological barrier to increasing the bike modal share [1] [16] [17] [18] [19]. While bicycling is known to have numerous benefits over other transportation modes, such as reducing traffic congestion and improving air quality, it remains a relatively underutilized mode of transportation on many college campuses. This study aims to understand the needs of bicyclists living close to campus and identify reasons that keep them away from cycling to help reduce automobile travel, relieve congestion, and enhance environmental protection. The study analyzes students' (undergraduate and graduate students) perceptions and barriers towards cycling in a survey conducted at The University of Tennessee, Knoxville (UTK), USA. The main motive behind this study is to attain a comprehensive understanding of the needs and concerns of bicyclists and to improve bicycle planning on and around campus. By identifying the specific barriers that

prevent people from using their bicycles, administrators can develop targeted interventions that address these obstacles and encourage more people to cycle.

2. Literature Review

Universities are considered Trip Generating Poles (TGPs), meaning they generate a significant number of trips taken by students, faculty, and staff [20] [21] [22]. To minimize the impacts of these trips on the surrounding population, adequate planning is necessary. To create a sustainable environment on their campuses, universities worldwide are increasingly committed to reducing the adverse impacts of motorized transportation modes. Inequalities in bike riding, particularly concerning gender, are a growing concern [14] [15] [23]. Bicycling can significantly reduce the vehicle count on the streets, thereby reducing congestion, vehicle fuel consumption, and hazardous CO2 emissions. This mode of transportation also promotes a healthier lifestyle for university populations [2] [4] [24] [25]. Several studies have focused on the factors that impact cyclists' choice of route selection and trip rate [26] [27]. Many studies have found the 'travel time' as the most significant and critical factor for route selection among cyclists [28] [29] [30] [31]. The presence of bike facilities, vehicle density, capacity, conflicting environment, and pavement surface condition have also been found to be key determinants of bike modal choice [9] [32] [33]. Bicycling has been positively associated with trips other than work. Non-bicyclists tend to avoid biking due to perceived dangers or lack of safe route options. High-speed traffic and a high proportion of vehicular traffic raise cyclists' safety concerns [10] [34] [35] [36] [37]. Another study explored individual preferences for cycling environments and found the willingness of people to travel up to 20 minutes extra for a better facility [38]. Infrastructural weakness, such as the lack of bike-specific roadway infrastructure, forces bike riders to use shared paths with pedestrians and motorized traffic, which can lead to feeling unsafe while cycling [39] [40]. Providing bike-specific lanes, traffic signal controls, and other safety measures can improve the perception of safety and increase the legitimacy of cycling as a travel mode [41] [42]. Improving the bike-riders' view of safety while biking is therefore important in promoting cycling as a mode to commute [43] [44]. The discontinuous bike lanes may increase discomfort for cyclists [45]. People's attitudes and perceptions towards cycling can change as they start cycling, suggesting that people can be convinced to continue cycling once they have started using the cycle as a means of transport. However, a university setting varies from urban regions because the campus area is physically delimited, and access points can be controlled [46] [47] [48] [49]. Many studies found that the university campuses are unique because they have a young and active population, with non-stop movement the entire day, and sporadic schedules. Sustainable transportation policies on campuses can influence the mode choice of the entire population besides the campus community, making campus transportation policies and decisions critical [23] [50] [51]. While prior studies identified factors in-

fluencing cyclists' mode choice, the present study expands on this by incorporating individual attitudes into transportation mode choice modeling. This approach provides a more comprehensive understanding of travel behaviors within campus settings, contributing and advancing the literature on sustainable transportation planning within university campuses. The study focuses specifically on the UTK campus for understanding the dynamics of travel behaviors within a campus environment, pinpointing specific groups that could be targeted to increase the percentage of commuters who choose to cycle, and including individual attitudes as a factor in the modeling of transportation mode choices.

3. Data Description and Descriptive Statistics

The data is collected by conducting an online survey titled "Exploring UTK Campus Community's Perceptions and Barriers toward Bike Mode Choice", a sample is attached in Annexure 'A' to the report. The survey form was designed after reviewing past studies and considering the nature of trends among the students at the universities. The survey form was distributed among faculty, staff, and students at The University of Tennessee Knoxville (UTK) through online sharing. 217 responses were received from the respondents, 11 responses were removed being incomplete, and the remaining 206 responses (complete forms) were selected as the final dataset. For statistical analysis of the data, bike modal choice *i.e.*, 'Bike use around the Campus' is selected as the 'dependent variable,' whereas other social and behavioral variables included in the survey form are selected as 'independent variables.' The dependent variable was considered as a binary variable with 1 representing bike use around the campus while 0 representing commute to/around the campus through all other non-bike modes *i.e.*, personal vehicle, transit, walking, etc. The distribution of the dependent variable 'Bike Use around the Campus' is shown in **Figure 1**.

Descriptive Statistics

The descriptive statistics associated with the variables collected in the study are presented in **Table 1**. Most of the individuals who responded to the online survey were males (59.71%), whereas 40.29% of respondents were females. The response

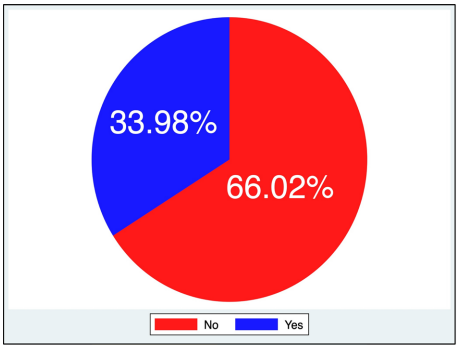

Figure 1. Distribution of the dependent variable.

Table 1. Descriptive statistics of the variables.

Variables	Descriptive Statistics (N = 206)			
	Frequency	Percentage %	Min	Max
Gender				
Male	123	59.71	0	1
Female	83	40.29	0	1
Age				
Less than 20 years	37	17.96	0	1
21 - 25 years	65	31.55	0	1
25 - 30 years	47	22.82	0	1
30 - 35 years	29	14.08	0	1
35 - 40 years	16	7.77	0	1
More than 40 years	12	5.83	0	1
Position at University				
Student	176	85.44	0	1
Faculty	6	2.91	0	1
Staff	24	11.65	0	1
Physical Disability				
Yes	10	4.85	0	1
No	196	95.15	0	1
School				
Graduate School	91	44.17	0	1
Undergraduate School	98	47.57	0	1
None	17	8.25	0	1
Living Arrangements				
On Campus	49	23.67	0	1
Off-Campus	157	76.32	0	1
Distance from Campus				
Less than 1 mile	62	30.10	0	1
1 to 5 miles	70	33.98	0	1
5 to 10 miles	48	23.30	0	1
More than 10 miles	26	12.62	0	1
Modes of Transportation To and From Campus				
Bicycle	25	12.14	0	1
Personal Vehicle	97	47.09	0	1
Public Transit Service	35	16.99	0	1
Walking	38	18.45	0	1
Others	11	5.34	0	1

Continued

More Choices to Travel to Campus Other than Driving				
Yes	121	58.74	0	1
No	85	41.26	0	1
Prefer Bike use around Campus				
Yes	70	33.98	0	1
No	136	66.02	0	1
Considering Riding Bicycle as an Opportunity to Exercise				
Yes	176	85.44	0	1
No	30	14.56	0	1
Flexible Arrival/Departure times from School/Work				
Yes	137	66.50	0	1
No	69	33.50	0	1
Improvement on Campus Encouraging Bicycling				
The directness of Travel of Bike Routes				
Yes	99	48.06	0	1
Campus Map indicating Bicycle Paths				
Yes	75	36.41	0	1
Repair Station for Bicycles on Campus				
Yes	49	23.79	0	1
Better Illumination on Campus				
Yes	65	31.55	0	1
Shower or Changing Clothes places on Campus				
Yes	80	38.83	0	1
Specific Bike Lanes on campus for cyclists				
Yes	69	33.50	0	1
Bike Riding and Safety Educational Classes				
Yes	32	15.53	0	1
Strict Traffic Laws for Cyclist Protection				
Yes	50	24.27	0	1
More Bike Runnels/Ramps				
Yes	52	25.24	0	1
Covered Bike Parking				
Yes	46	22.33	0	1
Major Issues that Deter Bicycling to or within the Campus				
No Biking Interest				
Yes	53	25.73	0	1
Mechanical issues of Bicycle				
Yes	39	18.93	0	1

Continued

Physical or Mental Impairments				
Yes	22	10.68	0	1
Worries about Crime making Bicycle Unsafe				
Yes	71	34.47	0	1
Vehicular Traffic Making Biking Unsafe				
Yes	97	47.09	0	1
Lack of knowledge of Biking				
Yes	41	19.90	0	1
Do not Own a bike				
Yes	67	32.52	0	1
Need to Change Clothes or Carry Things				
Yes	84	40.78	0	1
Inadequate Bike Lanes, Paths, or Trails				
Yes	70	33.98	0	1
Insufficient Lighting along Bike Routes				
Yes	43	20.87	0	1
Lack of adequate Bicycle Parking				
Yes	28	13.59	0	1

to the survey was received from almost all categories of people, one-third (31.55%) of the respondents were 21 to 25 years old, with individuals more than 40 years of age responding the least (5.83%). Although an effort was made to distribute the survey forms to the entire campus community *i.e.*, students (graduates/undergraduates), faculty, and staff, the students responded the most (85.44%), and among students, 44.17% were graduate students, whereas 47.57% were undergraduate students. Most of the respondents (almost one-third *i.e.*, 33.98%) lived within 1 to 5 miles of the campus, followed by individuals who lived less than 1 mile (30.10%), whereas 12.62% of the respondents lived more than 10 miles from the campus. Almost half of the respondents (47.09%) traveled to campus by their personal vehicles, as compared to bicycle riders (12.14%). More than half of the respondents (58.74%) considered they had more choices to travel to campus other than driving, and almost one-third (33.98%) preferred a bike to use around the campus. There is still a potential to convince more individuals toward biking. Since biking is a good way to exercise and remain healthy, 85.44% of the respondents considered riding a bicycle as an opportunity to exercise. More than two-thirds (66.50%) of the respondents had flexible arrival/departure timings from school/work, which shows a high potential for bike use within the campus.

In the survey form, suggestions were asked from the respondents regarding campus improvements to encourage more people towards bicycling, and they

were given choices to select any three among them. Almost half of the respondents (48.06%) selected the directness of travel of bike routes as their choice as they considered time the major factor in deciding the mode to travel. The existing campus map available online on the university website does not indicate all bike routes, therefore 36.41% of the respondents suggested an illustrated campus map indicating the recommended bicycle routes along with bike racks and repair stations to encourage more people to bike. The fear of any mechanical issues with the bicycle was highlighted as another major barrier discouraging people from biking, therefore 23.79% of the individuals suggested having repair stations for bicycles on campus, to facilitate the use of bicycles. Although most of the areas around the campus have better illumination, one-third of the respondents (31.55%) suggested having improved illumination on campus especially near bike routes to encourage bicycling. More than one-third (38.83%) of individuals suggested having showers and facilities for changing clothes on campus to allow students to take shower and change clothes before attending their classes. One-third (33.50%) of the respondents suggested having specific bike lanes for cyclists, whereas 24.27% emphasized imposing strict traffic laws for cyclists' protection, and 15.53% suggested arranging bike riding and safety educational classes on campus to encourage more people to bike. Around 25% of respondents suggested having more bike runnels/ramps, whereas 22.33% recommended covered bike parking on campus to encourage bicycling.

Finally, the respondents were asked to highlight the major issues and barriers that deter them from bicycling to or within the campus. They were given choices to select any three among them. In response, one-fourth of the respondents (25.73%) cited the lack of interest as the primary factor that keeps them away from biking, whereas 18.93% of individuals considered the mechanical issues of the bicycle as a barrier discouraging them from biking. 10.68% stated physical or mental impairment as a major barrier, whereas more than one-third (34.47%) stated that they felt unsafe or worried about crime while biking on campus after dark. Almost half of the respondents (47.09%) considered vehicular traffic as the reason for feeling unsafe while biking, and emphasized having separate bike routes, whereas 19.90% of individuals stated the lack of knowledge on biking as a major barrier discouraging them from bicycling. 40.78% of respondents highlighted the need to change clothes or carry things as the reason for not selecting bikes as a mode of transport at the campus, whereas more than one-third (33.98%) considered inadequate bike lanes, paths, or trails as a major barrier. 20.87% highlighted insufficient lighting along bike routes as the barrier, whereas 13.59% of the respondents considered the lack of adequate bicycle parking as a major barrier deterring bike use within the campus. Note that the responses under the "Improvement on Campus Encouraging Bicycling" and "Major Issues that Deter Bicycling to or within the Campus" are not mutually exclusive as every respondent selected any three choices among the set of provided choices under these questions in the survey. Graphical visualizations of the independent variables are shown in **Figure 2**.

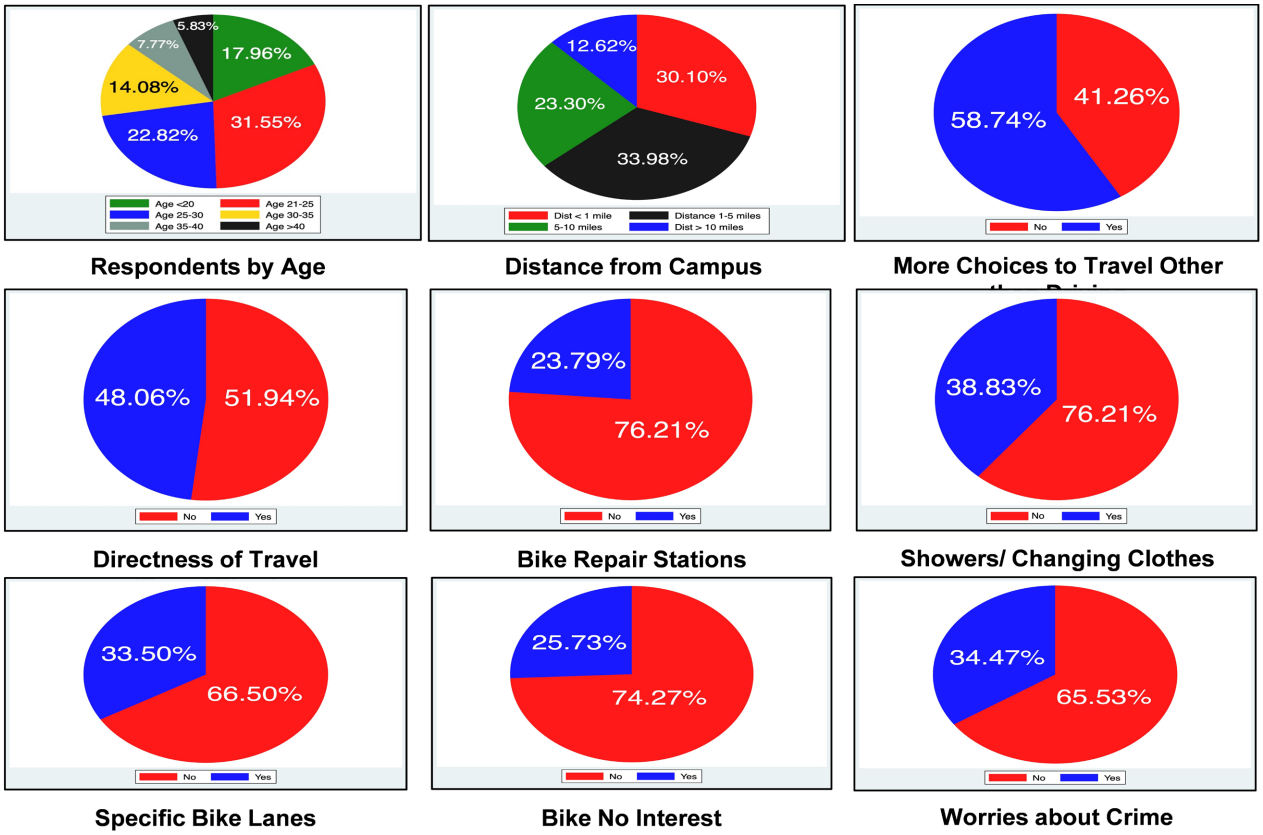

Figure 2. Graphical visualization of key independent variables.

4. Methodology

4.1. Conceptual Framework

The conceptual framework for the study is provided in **Figure 3**. The study aims to study the impact of the influencers and barriers related to bike use at campus along with the perceptions of individual bike users toward bike modal choice at the campus.

4.2. Overall Study Framework

The graphical representation of the overall study framework is presented in **Figure 4**. The study collects data from the campus community on bike modal share at the campus through an online administered bike use survey. After removing incomplete responses, descriptive statistics and a binary logit model is estimated for the final dataset containing perceptions of the campus community on bike modal share at the campus. Suitable recommendations to improve bike modal share at the campus are suggested based on the statistically significant factors influencing bike use at the campus that are obtained through the estimation of the binary logit model.

4.3 Results of Binary Logit Model

Table 2 presents the results of a binary logistic regression applied to model the

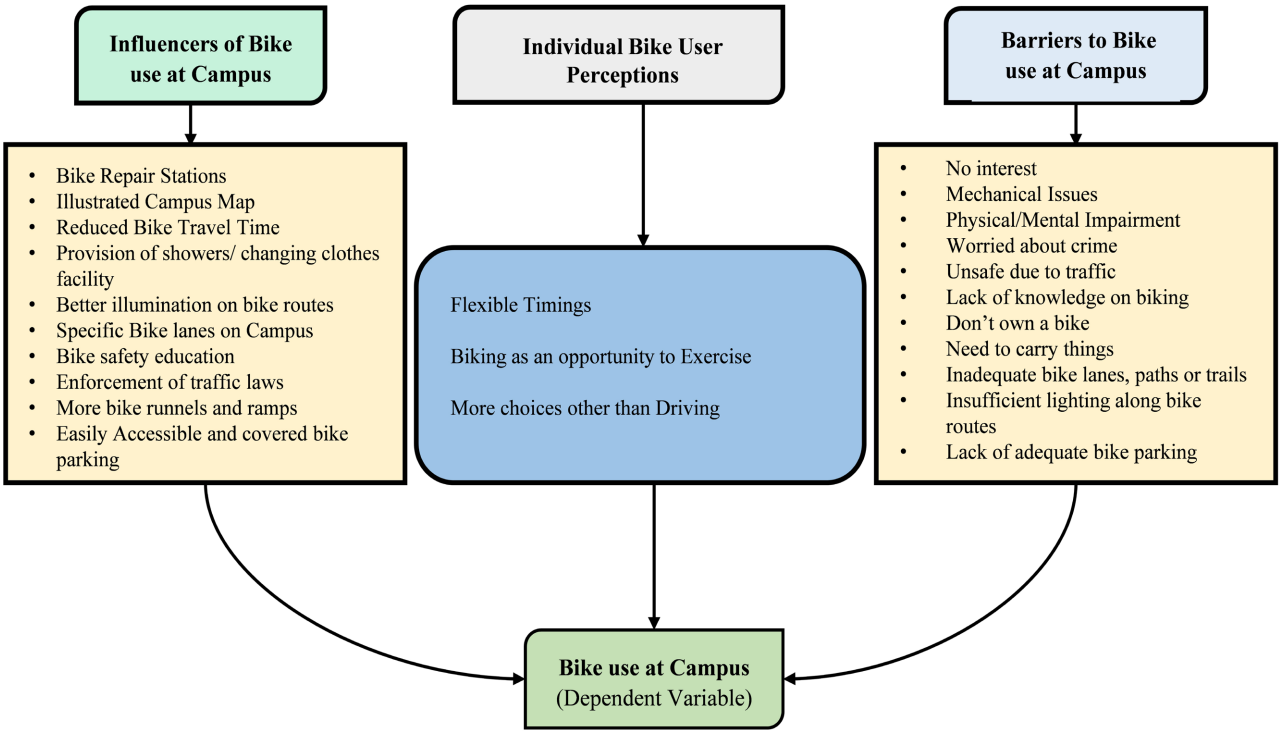

Figure 3. Study conceptual framework.

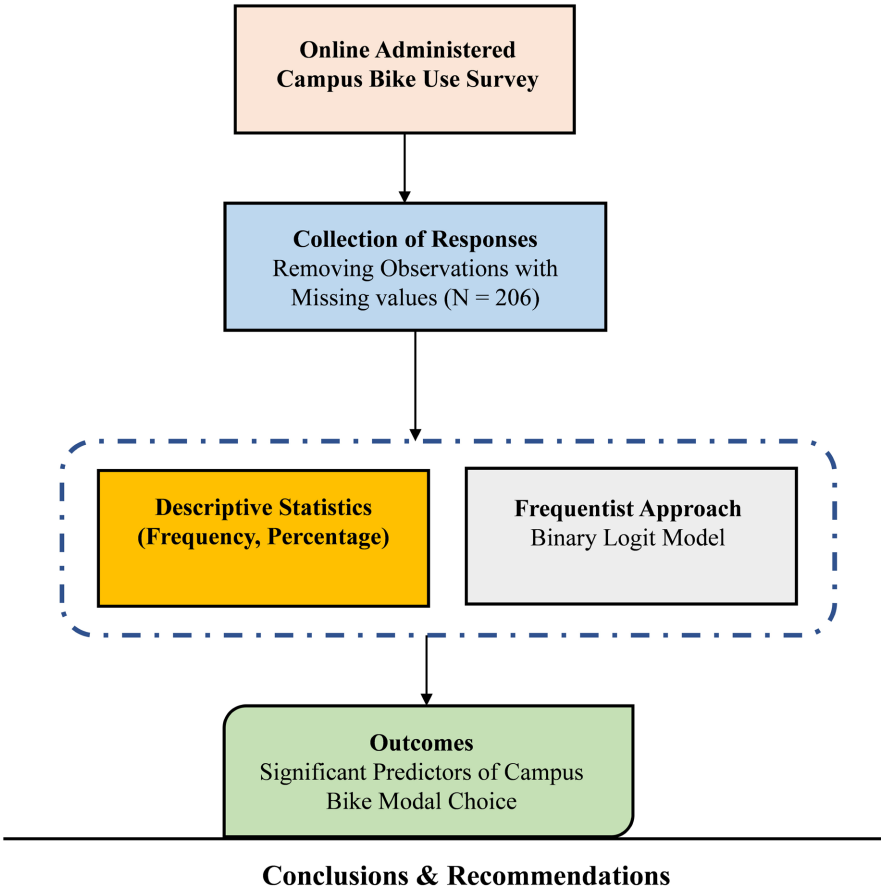

Figure 4. Overall study framework.

Table 2. Results of the binary logit model.

Variable	Coefficient	t-stat	p-value	Marginal Effects	
				Bike use	Other modes
Constant	−3.263	−4.53	0.000		
Need to carry things	−2.00	−3.57	0.000	−0.2753	0.2753
Reduced Travel Time	1.317	2.90	0.004	0.1813	−0.1813
Better illumination along bike routes	1.717	3.73	0.000	0.2362	−0.2362
Illustrated campus bicycle map	1.064	2.54	0.011	0.1464	−0.1464
Provision of showers in campus buildings	0.202	2.58	0.010	0.0684	−0.0684
Specific bike lane	0.132	2.15	0.031	0.1127	−0.1127
Bike safety awareness sessions	1.356	2.80	0.005	0.1867	−0.1867
Feeling unsafe due to Vehicular Traffic	−0.167	−4.47	0.000	−0.4774	0.4774
Worries about crime	−1.124	−2.56	0.011	−0.1546	0.1546
Physical disability	−1.971	−2.12	0.034	−0.2712	0.2712
More bike runnels and ramps	1.071	2.45	0.014	0.1474	−0.1474
The Goodness of Fit Statistics					
Number of Observations	206				
Log-likelihood at zero	−132.0268				
Log-likelihood at convergence	−97.1588				
Pseudo R-squared	0.264				
LR chi^2 (11)	89.74				
Prob > chi^2	0.000				
AIC	198.3177				
BIC	238.2522				

mode choice of biking at the UTK campus. Model results reveal that the reduction in travel time associated with biking at the campus is more likely to result in increased bike share at the campus. Marginal effects for the reduced travel time indicator show that the probability of bike use increases by 0.1813 when the value of this indicator switches from 0 to 1. Better illumination along bike routes is found positively associated with an increased modal share of bikes at the campus. Marginal effects for this indicator reveal an increase in the probability of bike use by 0.2362 for a change in the value of this indicator variable from 0 to 1. This finding indicates that through better illumination along bike routes, people's perception of safety while biking at night will increase which will eventually lead to more bike use on campus at night and/or in dark conditions. The development of a comprehensive campus bike network map showing bike routes and bike repair stations at the campus was found significantly associated with

increased bike use at the campus. Marginal effects for this indicator reveal an increase in the probability of bike use by 0.1464 for a change in the value of this indicator variable from 0 to 1. A detailed campus bike network map with information about bike racks, bike routes, and bike repair stations is expected to encourage the students to use bikes more often on campus. The provision of communal showers for students at campus buildings and departments is found more likely to increase the modal share of bikes at the university. The marginal effects for this indicator variable reveal that the probability of bike use increases by 0.0684 for a change in the value of this indicator variable from 0 to 1. Designating bike-specific lanes on the campus is found to be more likely to result in increased bike use among the campus community. The provision of more bike runnels and ramps at the campus is also found to increase the modal share of bikes. Marginal effects for this indicator indicate that the probability of bike use increases by 0.1127 for a change in the value of this indicator variable from 0 to 1. Bike safety awareness seminars conducted at the university campus are found more likely to increase bike use among the campus community. Such seminars can help spread awareness about bike safety and traffic rules to be observed while biking, resulting in persuading more non-bikers to adopt biking as a mode of transport around the campus. Feeling unsafe while biking at the campus due to vehicular traffic is found significantly associated with reduced bike use at the campus. The marginal effects for this indicator variable reveal that the probability of bike use decreases by 0.4774 for a change in the value of this indicator variable from 0 to 1. The unsafe behavior of car drivers toward bike riders at the campus can discourage bike use among students at campus. This result provides evidence in favor of the provision of bike-specific infrastructure such as bike lanes on the campus to help cyclists feel safer while biking. The indicator of bike users worried about being a victim of a crime while biking after dark is found significantly associated with reduced bike use at the campus. The marginal effects suggest a decrease in the probability of bike use of 0.1546 for a change in the value of this indicator variable from 0 to 1. This result implies that the university administration should ensure better safety on campus for bike riders. The indicator variable representing the need to carry things while moving around campus was also found to decrease bike use at the campus. The marginal effects for this indicator variable reveal that the probability of bike use decreases by 0.2753 for a change in the value of this indicator variable from 0 to 1. The provision of lockers to students to keep their belongings in campus buildings can be a potential solution for this issue. Students with any physical disability or health issues were found less likely to use bikes for commuting around campus. This finding is intuitive as people with health issues such as obesity, lack of stamina, or physical disability are more inclined towards using more comfortable motorized modes of transportation.

The model goodness of fit statistics indicate a log-likelihood at convergence value of −87.1588 and a Pseudo R-squared value of 0.3398 which indicates a better model fit as generally a Pseudo R-squared value higher than 0.20 demon-

strates a good model fit. The chi-squared test indicates that the model is overall statistically significant as the probability of getting a higher value than the chi-squared distributed likelihood ratio is 0.000. The values of Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), which are measures of prediction errors in the model are 198.3177 and 238.2522, respectively.

5. Conclusion

This study analyzes the UTK campus community's perceptions and barriers toward bicycle use on campus. The study objectives are to attain a comprehensive understanding of the needs and concerns of bicyclists and to improve bicycle infrastructure planning on campus. The study collects feedback from the campus community on the determinants of modal share of bikes at the campus through an online administered survey. The data collected from the survey was analyzed using a binary logistic regression model to determine the factors significantly influencing bike modal share at the campus. The study results revealed interesting insights into the perceptions of students, staff, and faculty toward bike use on campus. According to the study results, the factors found to significantly increase bike modal share among campus community were reduced travel time associated with biking *i.e.*, more directness of bike routes, provision of bike-specific and bike-supporting infrastructure such as bike lanes, bike runnels, ramps, showers, lockers, etc., improved lighting along bike routes, comprehensive mapping of the campus bike network, and bike safety awareness programs. The factors found significantly associated with discouraging bike use among the campus community included people feeling unsafe while biking at the campus due to vehicular traffic, worried about crime while biking around campus in dark conditions, the need to carry things while moving around the campus, and physical impairments/disabilities. Like all other studies, this study also has some limitations. The results obtained through the binary mode choice model in this study specifically reflect the perceptions of the campus community at the University of Tennessee, Knoxville. The results may not be generalizable to other campus locations or other cities or states. Furthermore, the limited sample size is a hindrance in the estimation of more robust sophisticated statistical models (random parameter models with heterogeneity in means or variances) or machine learning techniques to predict the enforcers and barriers to bike use in a university campus setting.

6. Recommendations

The study suggests various countermeasures based on modeling results that can potentially increase bike modal share around the campus. Firstly, a campus bike network needs to be developed with designated bike lanes, bike runnels, and ramps around the campus to ensure congestion-free bike travel around the campus. A detailed campus bike network map with information on bike routes, bike trails, bike repair stations, etc. needs to be developed. Since motorized traf-

fic on campus was found to make bike users feel unsafe, careless driving from the car drivers on campus should be dealt with strictly, imposing heavy fines and stringent penalties on car drivers in case of a crash with cyclists. Since the survey respondents revealed their concerns about safety on campus, especially in the evening or in dark conditions, citing improper or inadequate lighting as a key reason that discourages them from cycling, the study proposes increased security provided by the campus police, installation of safety cameras, and better lighting at the campus to ensure bike-user safety, especially in dark conditions. Bike-supporting infrastructure such as communal showers need to be provided in campus buildings to allow students to take showers after bike rides before attending classes or any meetings. The provision of lockers for students to keep their belongings is suggested in all campus departments to make sure that students do not have to carry many things while using bikes on campus. Bike safety awareness sessions arranged by campus police or safety practitioners are also suggested to educate bike users regarding traffic rules to be observed while biking to improve bike user safety.

The study contributes to the available literature by examining the travel behaviors within a campus environment (specifically, UTK), pinpointing specific groups that could be targeted to increase the percentage of commuters who choose to cycle, and including individual perceptions and preferences as a factor in the modeling of transportation mode choices. The study findings can assist policymakers and safety practitioners to better understand the influencing factors and deterrents of bike modal share in a university campus setting. It is hoped that sustainable transportation policies on university campuses can influence the mode choice of the public besides the campus community, making campus transportation policies and decisions critical to achieving sustainable transportation development.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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